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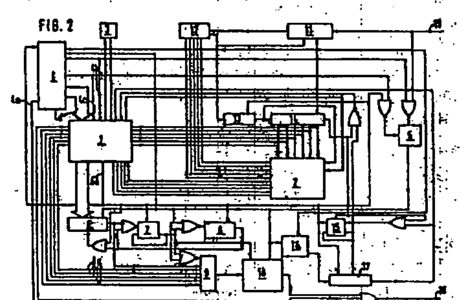
(54) **Circuit device for implementing the access protocol for serial exchange of numerical informations among terminals interconnected by an optical fiber star network.**

(57) The present invention relates to a device for implementing the access protocol for serial exchange of numerical informations among terminals interconnected by an optical fiber star network, using queuing state transmission in a small fraction of information channel capacity, thanks to a circuit for measuring the distance from each terminal to star center, which allows to synchronize the queuing state transmission minimizing the physical occupation of transmission channel, the delay queuing for accessing to the network being managed by an access algorithm, processed by the device itself, which is provided in each terminal of the network.

FIG. 2



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Description

"CIRCUIT DEVICE FOR IMPLEMENTING THE ACCESS PROTOCOL FOR SERIAL EXCHANGE OF NUMERICAL INFORMATIONS AMONG TERMINALS INTERCONNECTED BY AN OPTICAL FIBER STAR NETWORK"

The present invention relates to a circuit device for implementing the access protocol for serial exchange of numerical informations among terminals interconnected by an optical fiber star network, preferably usable in Local Area Networks (LAN) for voice and data transmission.

As it is known, optical telecommunications utilize optical guides, called optical fibers because of their structure which, by connecting a plurality of user terminals, can establish a network whatever complicated.

If all network terminals are connected to a sole central node, the network is called star network.

The central node can be either active (signal repeater or switching network) or passive (optical signal coupler). In both cases, terminals can exchange each other numerical informations, namely code pulse sequence coded informations, in serial form. That means that pulses of any sequence are subsequently transmitted one after the other in packets, observing a certain access protocol.

The desired requirements of an access protocol to network by terminals real-time operating are:

a) efficiency independent of transmission speed of code pulse packets;

b) efficiency independent of both static transmission charachteristics of users and traffic distribution provided by said users;

c) distribution of packet transmission delay over a small value range;

d) ability to accept different distributions of such delay for different user classes;

e) structure enabled to communication with other networks.

In the current art, in order to meet such requirements, access protocols based on possible conflict prevention techniques are used in optical fiber star networks.

A first typical example is the CSMA-CD (Carrier Sense Multiple Access with Collision Detection) technique.

With this technique, a terminal sends a message immediately after having ascertained that the channel is clear. To this end, the received signal level is continuously monitored in order to detect even possible collisions among messages which have been transmitted simultaneously, since, if this is the case,the received signal level is changed. After having detected a collision, the involved terminals do not transmit anylonger and, if the channel is clear, they retransmit, for example, only after a period having a random duration, or in other ways.

With an access of this type, a great efficiency is achieved if transmission intervals, and then the code pulse packets, are long and if signal propagation time among terminal pairs of the same network (propagation delay) is short.

This is disadvantageous for high transmission speeds as, with these latters increasing, the packet transmission time becomes shorter and shorter with respect to signal propagation time into the network.

A second example of a conflict prevention technique for access protocols allows to overcome this latter difficulty. With this technique a queuing state transmission is used, so that each terminal can recognize the position of all network users in a delay queuing. This allows the automatic allocation of message transmission times, ensuring channel utilization efficiency, which is independent of distribution and traffic characteristics.

This solution, however, has the following drawbacks:

- it requires a queuing state transmission protocol on which the disadvantages to be eliminated are reproduced;
- the queuing state transmission involves a transmission capacity wasting due to the effect of propagation time.

The object of the present invention is to overcome the above-mentioned drawbacks as regards circuits nowadays in use, by carrying out and providing a circuit for implementing the access protocol for serial exchange of numerical informations among terminals interconnected by an optical fiber star network, which allows the serial exchange of information among terminals in an manner which is entirely asynchronous and independent of transmission speed, of transmission delay distribution and of traffic and transmission characteristics distribution.

This and other objects, which will be better understood from the following description, are met by a circuit device for implementing the access protocol for serial exchange of numerical information among terminals interconnected by an optical fiber star network, characterized in that it includes a microcomputer, provided with a Random Access Memory to store queuing states and messages, as well as with a Read Only Memory, for physical addresses of all terminals, which microcomputer controls, at the beginning, a distance meter for measuring the distance from star center of each terminal, by activating its oscillators, beginning from the nearest to the center and then enables a delay state counter, whose end-of-counting pulse switches a flip-flop which, in turn, enables timings of an 8-bit counter, of a parallel/series converter shift register and of an encoder from NRZ to Manchester-code for transmission, which is interrupted by switching over, in a reset state, said flip-flop after having the 8-bit counter effected the end-of-counting, this latter timing the counter of queuing state sequences, whose outputs address the buffer RAM to store queuing states which, being read by the microcomputer, are transferred by this latter to its bus memories, setting the entire circuit for a new transmission-reception cycle.

Further characteristics and advantages of the present invention will become more apparent from the following detailed description of a preferred but

not exclusive embodiment, with reference to the accompanying drawings, in which:

figure 1 shows the steps of terminal access to the network,

figure 2 shows a general diagram of an embodiment of a serial access circuit to an optical fiber star network according to the present invention.

The description mainly refers to queuing state reception and transmission, which represent the most important aspect of circuit operation; the transmission and reception of real information messages, is more briefly described without this involving limitation, being the transmission pattern the same, which requires in addition, only a memory extent binded to different format of code pulse packets of information messages.

Besides, even though it is possible to have the circuit according to the present invention with the highest use flexibility as to number of terminals, optical cable lenght, data packet format, transmission speed, the following description relates to, as merely indicative and not limitative example, an optical star network which interconnects 64 terminals at the most, which transfer messages at 140 Mbit/sec, with coding for 5-bit queuing states.

Before examining further circuit details, it becomes necessary to make some remarks.

In a star network the sole resource common to all terminals is star center: this resource is to be used in time-division in case of a numerical transmission with light of a given wavelenght on optical fibers star-interconnected through a sole center node.

Therefore, when a message sent by a terminal is passed through star center, this one, and thus the network, is unavailable for switching another message. Then the queuing delay management can be made in a simple and automatic manner if each terminal knows its own distance from star center and thus the delay time from and to star center. This object can be reached by providing each terminal with a control circuit for entering the network according to the following formalities.

During the inizialization phase, each terminal measures its distance from star center by transmitting a suitable signal. In order to avoid collisions, and thus an incorrect measure, each terminal transmits in sequence according to its own physical address.

Once the time in which transmitted signals from each terminal reach the star center has been determined, it is possible to establish a transmission sequence of queuing states so that, when synchronization is effected, terminals transmit queuing states in order that their flow is uninterrupted.

Likewise, a terminal which has to transmit an information packet starts its transmission with a suitable ahead of time, so as to minimize the time interval of the transit through star center between consecutive packets of informations.

Access of terminals to network is illustrated in fig. 1.

During inizialization phase (fig.1a), signals on network are the following:

- first, measuring signals of distances (interval D) are sent;
-after having each terminal performed a distance measurement, one of the terminals, for istance the closest to star center, transmits a driver message P in order to synchronize queuing state transmission from all terminals:
- the terminals then transmit respective queuing states in time-division, during interval CO;
- the terminal closest to star center transmits a driver message once again, in order to give the circuit of queuing algorithm time to decide the trasmission queuing and keep the synchronism;
- a second sequence of queuing states is then in time-division, transmitted, during time interval C1;
- at this point, during time interval M1, a time-division transmission of code pulse packet of information messages, is started by terminals, according to a transmission sequence determined from queuing state sequence, which is received during interval CO.
- a sequence of queuing states C2 as well as the code pulse packet serie of information messages, is then transmitted according to a transmission order determined from a queuing state sequence received during interval C1, and so on.

When the inizialization phase is ended, frame sequences QI follow on the network, all of them formed by a sequence transmission of queuing states, during time interval CI, and by a code pulse packet series of information messages, during time interval MI (fig. 1b).

The queuing state sequence of all terminals is updated at each frame QI and the queuing algorithm circuit decides the transmission queuing of terminals in QI, according to a code state sequence, which is received in a previous frame Q (I-I).

Within a time interval CI a queuing state sequence is time-division transmitted for all network terminals. If a terminal is not active, it is also assigned a time channel in CI. This allows to facilitate both the terminal access not still active and a growth of the system. To this end, when a new terminal is connected to the network, or when a terminal is shifted, changing its distance from star center, the present phase take place again with a measurement of distances between terminals and star center. Distance values are stored in a nonvolatile storage of microcomputer of each terminal. Therefore, if a terminal is activated when other terminals are already active, it can already transmit its own queuing state into temporal channel, which is assigned to it in CI, and syncronize its own oscillator on received signals, after the end of queuing state sequences transmission, enabling a transmission from a subsequent frame Q (I + I).

For each terminal, the queuing state code contains information on type of message to be transmitted and on its priority. Terminals transmit in an order settled by a queuing algorithm circuit according to such information, in a fully asynchronous manner, then the same terminal may also take up several time channels of transmission interval of informations MI of the same frame QI.

In any case, in order to ensure a separation among subsequent information packets, adjacent time channels are divided by a time interval having a

period of a least three code pulses. Information packets are switched among terminals, ensuring the best allocation of transmission delay related to the transmitted signal type. To this end, at each frame, priorities are updated according to queuing state sequence, taking in account delay times of transmission shift.

If, after a transmission cycle, no messages are to be transmitted, the terminal, which has transmitted last, sends a driver message, in order to allow a maintenance of synchronization and a commencement of another transmission cycle, as in the inizialization phase (fig. 1c).

As it can be seen from fig. 2, transmission and reception are controlled by a microcomputer 1, which processes distance measurement, queuing states and controls and synchronizes the various phases of circuit operation.

Most of logic circuitry out of microcomputer works at high speed (140 Mbit/sec) and therefore an interface between microcomputer and outside logic, formed by a random access memory (RAM) 2 for storing queuing states and messages is necessary.

The circuit includes a read only memory (ROM)3, in which all physical address of all terminals are stored. In the inizialization phase, a microcomputer 1 controls, when involved, the measuring of distance between star center and telemetering circuit 4, according to a sequence determined by sequence of physical terminal addresses, which is included in ROM 3.

When distance measuring is terminated, each terminal transmits its value to all other terminals. The terminal included among those active, which is the closest to star centre, enables its own oscillator 5 and sends a driver message 4a to all other terminals, synchronizing their oscillators 5, generating clock signal at 140 Mbit/sec. At the same time, the microcomputer sets on a certain initial value, depending on the distance between terminal and star centre, the counter 6, the counting time of which establishes the time delay in that terminal between the beginning of the reception of the driver message and the beginning of the transmission of its own queuing state. The latter consists of 5 code-bits (9a) originating from the microcomputer, containing information about the type of packets and its transmission priority.

The end-of-counting pulse of delay state counter 6 switches the flip-flop 7, which enables timings of a bit counter 8, a parallel-series converter shift register 9, and an encoder 10 from NRZ to Manchester-code. By means of these circuits, queuing state bits, received from register 9, are counted, serialized and coded to Manchester-code for transmission.

The end-of-counting pulse of the bit counter 8 indicates that the queuing state has been transmitted and switches the flip-flop, previously driven, into rest state, disconnecting transmission circuits.

Distance measuring operation during the inizialization phase is effected by the distance counter 4 which, after an enabling counting signal 4b, receives a timing signal syncronized with the transmission clock signal at 140 Mbit/sec, with which it can measure the appearance delay of signal echo transmitted by terminal itself sent back from star center, counting the number of clock signal periods, which correspond to this delay.

At 140 Mbit/sec, this period amounts to 7 nsec and if, for example, the propagation delay, corresponding to the maximum terminal-node distance, is 5000 nsec, periods to be counted are 5000/7=714 and, thus, in this case, it is sufficient to use a counter module 1024. The first positive edge of echo signal received by distance counter 4 stops counting and causes the sending of an end counting signal 4c from circuit 4 to microcomputer, which thus can fetch the distance measuring code 4d.

This measure has an accuracy that is roughly equal to one period of the clock signal: thus, it is necessary to space the queuing state transmission of terminals at least three code pulses, in order to avoid possible overlaps.

The receiving circuit of queuing states is the same employed for receiving messages and, thus, is dimensioned according to packet format of code pulses forming the messages; in the following, a reception and abstract of queuing states, is described according to the present invention.

During the inizialization phase, the microcomputer of each terminal, when transmission of its own signal for the distance measurement is ended (within time interval D of fig. 1a), sends the circuit a reset signal 5a enabling it for receiving the driver message 4a, transmitted by the active terminal which is the star center's nearest one,a message which enables the synchronization of the clock signal generator oscillator 5 at 140 Mbit/sec with the homologous oscillators of all other terminals.

At this point, each terminal receives the first sequence CO of queuing states from all terminals and for a second time the driver message 4a from the active terminal which is the star center's nearest one, during the duration of which the queuing algorithm is processed through the microcomputer.

The acquisition of queuing states takes place as follows: the code pulses of each queuing state, which are being received, are decoded from manchester-to NRZ-code into the decoder 11 and feeded to a shift series-parallel converter register 12 and simultaneously transmitted to the code pulse counter 13 which, every 5 pulses, sends an end-counting pulse which synchronizes the counter 14 of queuing state sequences, whose outputs address the RAM 2 for storing queuing states (from 5 bits each and relevants to no more than 64 terminals in the illustrated merely indicative and not limitative example).

Once all of queuing states have been stored into RAM2, the counter of queuing state sequences 14 sends an end-of-counting pulse which, received by microcomputer, enables a reading operation of RAM 2 and the transfer of queuing states into its bus memories.

The same end-of-counting pulse of counter 14 triggers the flip-flop 15, the output of which:

- transmits the signal of end-of-queuing state sequences to microcomputer which, when is the duty of terminal to which it belongs, can enable the

message transmission;
- enables the passage at the output of signal from control circuit 16 which monitors the message lenght timing the counter of message number 17, whose end-of-counting pulse is the end-of-messages pulse transmitted to microcomputer, which sets the entire circuit for a new transmission 18 and reception 19 cycle.

In this way, the present invention reaches the proposed objects. In fact, by means of such a circuit it is possible to obtain an operation which permits an asynchronous information exchange among terminals of a star network apart from transmission parameters.

Obviously, several changes and variants concerning both the structure and the program can be made in the device, according to the present invention, without being out of the sphere of the inventive concept.

Claims

1. Circuit device for implementing the access protocol for serial exchange of digital information among terminals interconnected by a star network, characterized in that it includes, in a terminal, a microcomputer (1) provided with a first memory (2) to store queuing states and messages and with a second memory (3) to store addresses of all the terminals, distance measuring means (4) for measuring the distance between the terminal and the center of the star network, driving message receiving means (5) to receive a driving message transmitted in an initialization phase by one designated terminal, as well as queuing state transmission delay means (6) measuring a time delay from the reception of a driving message to the transmission of a queuing state depending on the measured distance, so as to initiate sending of the terminal own queuing state within an uninterrupted sequence of the queuing states of all the terminals, the queuing states received from all the terminal being subsequently used to determine the order according to which terminals will be allowed to transmit information messages.

2. Circuit device according to claim 1, characterized in that said distance measuring means includes a counter (4) counting clock pulses from the transmission of a distance measuring signal to the star network center to the reception of the same message sent back to all terminals by the star center.

3. Circuit device according to claim 2, characterized in that each terminal send a distance measuring signal in an initialization phase, in a sequence determined by the addresses of the terminals as stored into said second memory (3).

4. Circuit device for implementing the access protocol for serial exchange of numerical informations among terminals interconnected by an optical fiber star network, characterized in that it includes a microcomputer, provided with a random access memory (RAM) (2) to store queuing states and messages, as well as with a read only memory (ROM) (3) for physical addresses of all terminals, which microcomputers controls, at the beginning, a distance meter (4) for measuring the distance from star center of each terminal, by activating its oscillators, beginning from the nearest to the center and then enables a delay state counter, (6) whose end-of-counting pulse switches a flip-flop (7) which, in turn, enables timings of an 8-bit counter, of a parallel-series converter shift register (9) and of an encoder from NRZ to Manchester-code (10) for transmission, with is interrupted by switching over, in a reset state, said flip-flop (7) after having the 8-bit computer effected the end-of-counting, this latter timing the counter of queuing state sequence, whose outputs address the buffer RAM to store queuing states which, being read by the microcomputer, are transferred by this latter to its bus memories, setting the entire circuit for a new transmission-reception cycle.

5. Circuit device according to any one of claims to 4, characterized in that instead of a microcomputer it is used a wired logic sequential circuit.

6. Circuit device according to claim 5, characterized in that said microcomputer has an algorithm in order to control the queuing states for the access to the network.

7. Circuit device according to claim 6, characterized in that said algorithm allows the eventual connection of each terminal to other optical fiber star networks.

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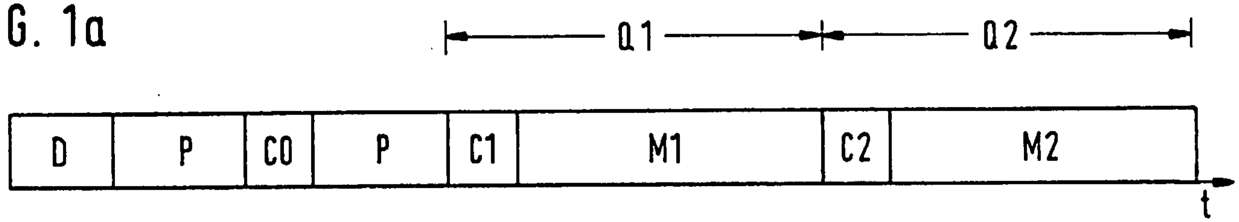
FIG. 1a



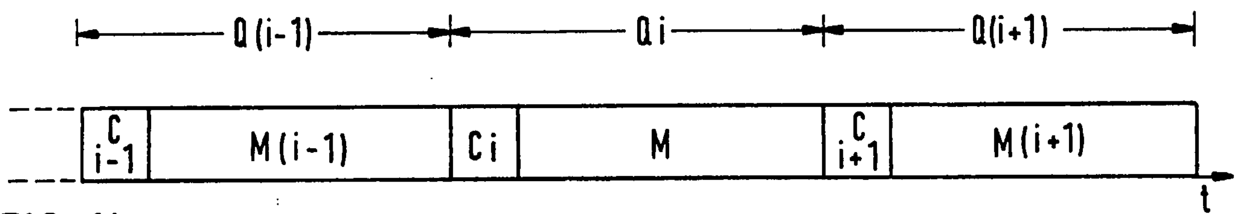


FIG. 1b

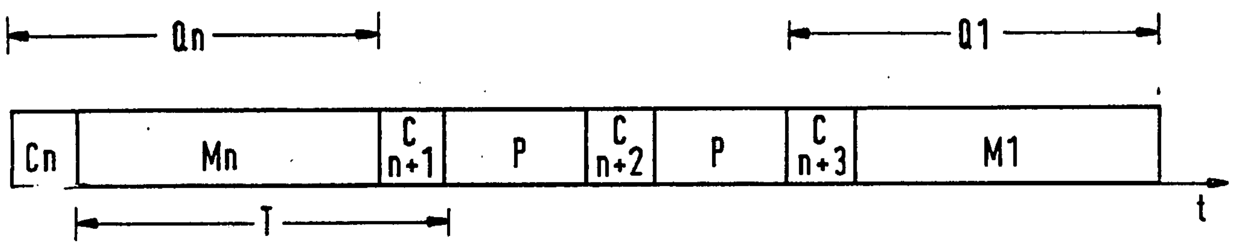


FIG. 1c

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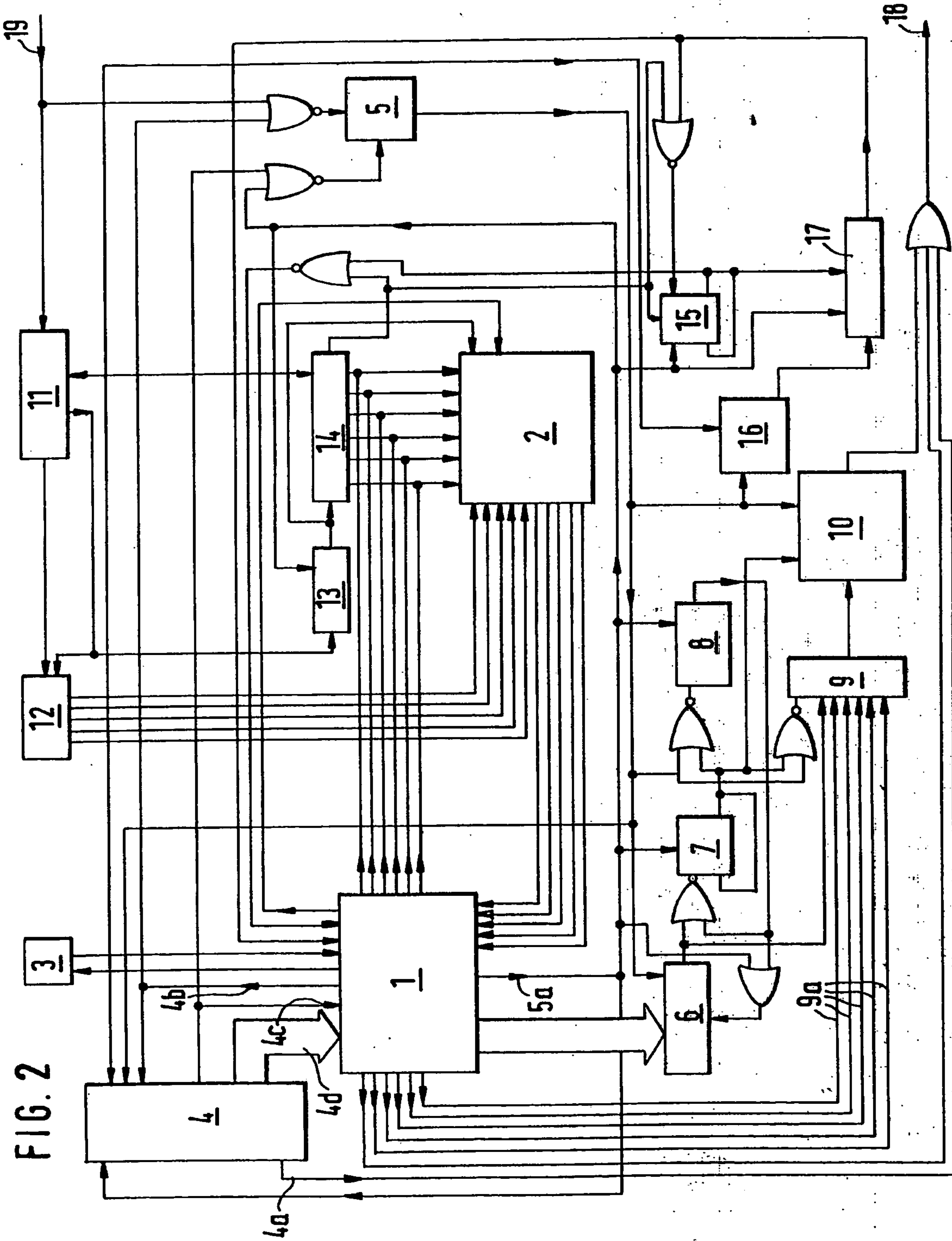

FIG. 2